APPENDIX 4-A

HY8 CULVERT ANALYSIS - MICROCOMPUTER PROGRAM

Data Input For Culvert

As an initial size estimate, try a 24 inch circular culvert. For the culvert assume that a conventional inlet with headwall and square edges will be used. As each group of data are entered the user is allowed to edit any incorrect entries. The following will show the computer screens that the user will see.

After inputting the word CULVERT to start the program the following will appear on the computer screen.

```
        CULVERT FILE MENU

   TYPE LETTER OF DESIRED OPTION

   <E>    EDIT OR USE A FILE

   <C>    CREATE A FILE

   <ESC> FOR MAIN PROGRAM MENU
```

Input a name for the file that will store all input data and press return to have the computer input the current date.

```
TYPE NEW CULVERT FILE NAME

FILE NAME ---> TEST


TYPE DATE OR <ENTER> FOR CURRENT DATE

DATE --->


<ESC> TO RETURN TO CULVERT FILE MENU
```

Input the design discharge (10-year peak discharge) and the maximum discharge (100-year peak discharge).

```
ENTER DESIGN AND MAXIMUM FLOW

<1> MINIMUN DISCHARGE (CFS)          0.0

<2> DESIGN  DISCHARGE (CFS)         60.0

<3> MAXIMUM DISCHARGE (CFS)        110.0


<NUMBER> TO EDIT DISCHARGE
<ENTER>  TO CONTINUE
```

Select <2> Culvert Invert Data

Input the culvert invert data which will be used to determine the length, slope, and elevations associated with this culvert installation.

```
              CULVERT INVERT DATA


NO.      ITEM                              VALUE

<1> INLET STATION (FT)                    100.00
<2> INLET ELEVATION (FT)                  950.00
<3> OUTLET STATION (FT)                   175.00
<4> OUTLET ELEVATION (FT)                 947.00
<5> ENTER NUMBER OF BARRELS                 1
```

Select a culvert shape (for this example a circular culvert was selected)

```
SELECT A CULVERT SHAPE:

   <1> CIRCULAR
   <2> BOX
   <3> ELLIPTICAL
   <4> PIPE ARCH
   <5> USER DEFINED (COORDINATES)
   <6> ARCH
   <7> LOW-PROFILE ARCH
   <8> HIGH-PROFILE ARCH
   <9> METAL BOX
```

Specify the culvert diameter to be used for the first analysis.

```
        CIRCULAR CULVERT

CULVERT DIAMETER (FT) ---> 2*

<ESC> TO RETURN TO SHAPE MENU
```

Select a culvert material (for this example a concrete culvert was selected).

```
SELECT A CULVERT MATERIAL:

<1> CONCRETE

<2> CORRUGATED STEEL PLATE

<3> CORRUGATED ALUMINUM PLATE
```

Select an inlet type (for this example a conventional inlet was selected).

```
SELECT AN INLET TYPE:

<1> CONVENTIONAL

<2> SIDE-TAPERED, CIRCULAR

<3> SIDE-TAPERED, RECTANGULAR

<4> SLOPE TAPERED
```

Select inlet conditions (for this example square edge with headwall was selected). Then specify if there is inlet depression (this example did not include any inlet depression).

```
SELECT AN INLET CONDITION:

   CONVENTIONAL INLETS

<3>  SQUARE EDGE WITH HEADWALL
<4>  GROOVED END PROJECTION
<5>  GROOVED END IN HEADWALL
<6>  BEVELED EDGE (1:1)
<7>  BEVELED EDGE (1.5:1)
```

Following is a summary table of the culvert input data.

```
    ITEM                        SELECTED CULVERT

<1> BARREL SHAPE:               CIRCULAR

<2> BARREL SIZE:                 2.00 FT DIAMETER

<3> BARREL MATERIAL:            CONCRETE

<4> MANNING'S n:                .012

<5> INLET TYPE:                 CONVENTIONAL

<6> INLET EDGE AND WALL:        SQUARE EDGE WITH HEADWALL

<7> INLET DEPRESSION:           NONE

<NUMBER> TO EDIT ITEM
<ENTER>  TO CONTINUE DATA LISTING
```

At this point the user can edit any of the input data or press <ENTER> to continue.

Data Input Downstream Channel

Following are the data related to the channel downstream from the culvert.

For the calculation of tailwater conditions, select the shape of the channel directly downstream from the outlet of the culvert (for this example a rectangular channel was selected).

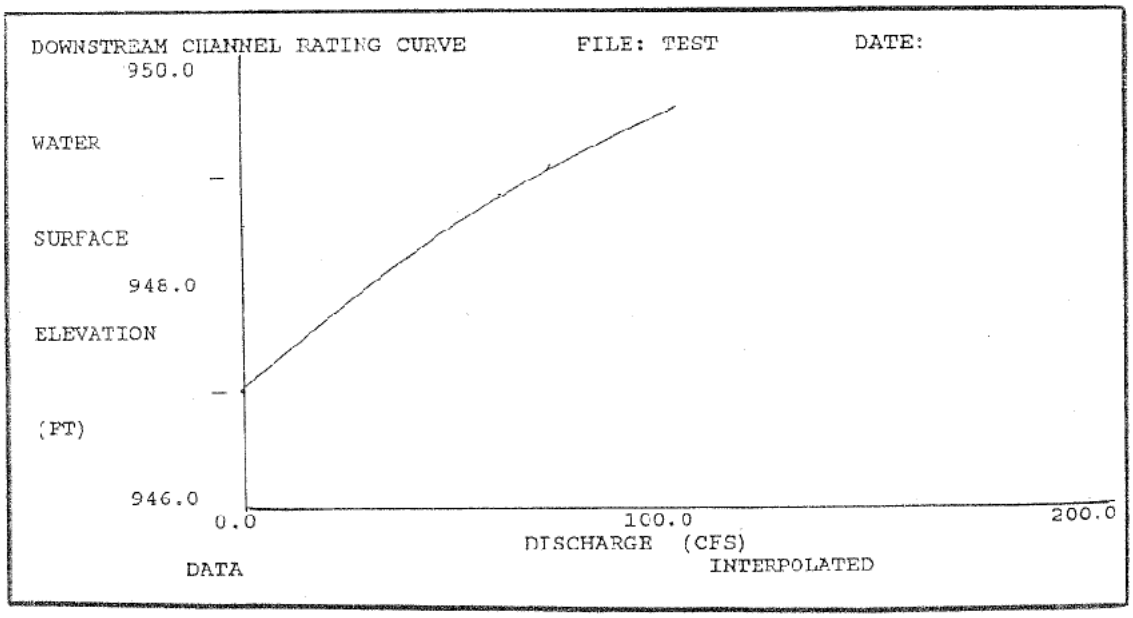
```
TAILWATER RATING CURVE

PRESS NUMBER OF OPTION

<1> RECTANGULAR CHANNEL

<2> TRAPEZOIDAL CHANNEL

<3> TRIANGULAR CHANNEL

<4> IRREGULAR CHANNEL (MAX. 15 COORDINATES)

<5> ENTER RATING CURVE (11 POINTS)

<6> ENTER CONSTANT TAILWATER ELEVATION
```

For the downstream channel, input the bottom width, channel slope, Manning's n, and channel invert elevation.

```
   ENTER TAILWATER CHANNEL DATA

NO.      ITEM                              VALUE

<1> BOTTOM WIDTH (FT)                        5

<2> SIDE SLOPE  H:V  __:1

<3> CHANNEL SLOPE (FT/FT)                  .04

<4> MANNING'S N (.01-0.1)                  .045

<5> CHANNEL INVERT ELEVATION (FT)          947

    CULVERT INVERT ELEVATION (FT)        947.00
    (CULVERT NO. 1 OUTLET)

<NUMBER>  TO EDIT ITEM
 <ENTER>  TO CONTINUE DATA INPUT
   <ESC>  FOR CHANNEL SHAPE MENU
```

The table showing the Tailwater Rating Curve Data will now be calculated by the model. By pressing P you can obtain a plot of the Tailwater Data (Downstream Channel Rating Curve).

```
                TAILWATER RATING CURVE

NO.    FLOW(CFS)   T.W.E.(FT) VEL.(FPS) SHEAR(PSF)
 1         0.00       947.00      0.00       0.00
 2        11.00       947.56      3.92       1.40
 3        22.00       947.88      4.97       2.21
 4        33.00       948.16      5.67       2.91
 5        44.00       948.42      6.19       3.55
 6        55.00       948.67      6.60       4.16
 7        60.00       948.77      6.77       4.43
 8        77.00       949.13      7.24       5.31
 9        88.00       949.35      7.50       5.86
10        99.00       949.56      7.73       6.40
11       110.00       949.77      7.93       6.93

          PRESS:
             <D> FOR DATA
             <P> TO PLOT RATING CURVE
           <ESC> FOR CHANNEL SHAPE MENU
         <ENTER> TO CONTINUE
```



Data Input Roadway

For overtopping analysis additional data will be needed about the roadway over the culvert installation.

Select a profile shape for the roadway above the culvert installation (for this example a constant roadway elevation was selected).

```
ROADWAY PROFILE SHAPE FOR OVERTOPPING ANALYSIS

        SELECT PROFILE SHAPE:

        <1> CONSTANT ROADWAY ELEVATION

        <2> IRREGULAR (3 TO 15 COORDINATES)
```

Input the crest length and overtopping crest elevation.

```
        ENTER PROFILE DATA

NO.     ITEM                        VALUE

<1> CREST LENGTH (FT)                50

<2> OVERTOPPING CREST
            ELEVATION (FT)           955*
```

Select a weir coefficient for the roadway section (for this example a paved roadway surface was selected).

```
                WEIR COEFFICIENTS

SELECT ROADWAY SURFACE OR A WEIR COEFFICIENT:

<1> PAVED ROADWAY SURFACE

<2> GRAVEL ROADWAY SURFACE

<3> INPUT COEFFICIENT OF DISCHARGE (2.5 - 3.095)


<ESC> FOR LAST MENU
```

Select an overtopping crest elevation.

```
     SELECTED OVERTOPPING CREST

<1> SHAPE:  CONSTANT ROADWAY ELEVATION 955 FT

<2> CROSS-SECTION DATA

<3> ROADWAY SURFACE:  P

<4> EMBANKMENT TOP WIDTH (FT): 60*
```

Following is a summary table of the data input.

```
CULVERT ANALYSIS 3.1                                          DATE:
CULVERT FILE: TEST                  SUMMARY TABLE             CULVERT NO. 1

 C |      <S>  SITE DATA          |      <C>  CULVERT SHAPE, MATERIAL, INLET
 U |-------------------------------|-------------------------------------------
 L |  INLET    OUTLET   CULVERT    | BARRELS
 V |  ELEV.     ELEV.   LENGTH     | SHAPE          SPAN   RISE  MANNING   INLET
NO.|  (FT)      (FT)     (FT)      | MATERIAL       (FT)   (FT)     n       TYPE
 1 | 950.00   947.00      75      | 1 - RCP        2.00   2.00   .012   CONVENTIONAL
 2 |
 3 |
 4 |
 5 |
 6 |

      PRESS  TO REVIEW                      PRESS  TO
       <C>   CULVERT DATA                    <E>   EDIT CULVERT SIZE
       <D>   DISCHARGE DATA                  <M>   MINIMIZE CULVERT SPAN
       <O>   OVERTOPPING DATA                <A>   ADD OR DELETE CULVERTS
       <S>   SITE DATA
       <T>   TAILWATER RATING CURVE

                          <ENTER>  TO CONTINUE
```

The user can now edit any data input either to correct errors or to try different analysis for different conditions or culvert designs.

Analysis

Overtopping Analysis - If the user wants to take into account roadway overtopping, then this alternative should be selected. Otherwise select the no overtopping analysis option. The model will then perform the flow analysis and calculate how much flow will pass through the culvert and how much flow will overtop the roadway. The user can then plot the culvert rating curve and/or print a summary of the culvert data and analysis.

```
                        CULVERT PROGRAM OPTIONS

                    PRESS LETTER OF DESIRED OPTION

                    <O> OVERTOPPING ANALYSIS
                        Inlet Control   - HDS5 Nomographs
                        Outlet Control - Full Barrel Flow
                        Overtopping     - Wier Equation

                    <N> NO OVERTOPPING ANALYSIS (CULVERT NUMBER 1)
                        Inlet Control   - HDS5 Nomographs
                        Outlet Control - Full Barrel Flow


                    <B> OUTLET CONTROL METHOD
                    <S> SAVE MENU
                    <D> DATA SUMMARY
                    <F> FILE MENU     SAVE FILE BEFORE <F> OR <M>
                    <M> MAIN MENU     OR FILE WILL BE LOST

1HELP   2       3       4       5END    6       7       8       9SHELL  10
```

SUMMARY OF CULVERT FLOWS (CFS) FILE: TEST DATE:

ELEV (FT)	TOTAL	1	2	3	4	5	6	OVERTOP	ITER
950.00	0	0	0	0	0	0	0	0	0
951.77	11	11	0	0	0	0	0	0	1
953.23	22	22	0	0	0	0	0	0	1
955.07	33	31	0	0	0	0	0	3	2
955.20	44	31	0	0	0	0	0	13	2
955.30	55	32	0	0	0	0	0	24	2
955.33	60	32	0	0	0	0	0	29	2
955.45	77	32	0	0	0	0	0	46	2
955.52	88	32	0	0	0	0	0	55	2
955.58	99	33	0	0	0	0	0	67	2
955.64	110	33	0	0	0	0	0	78	2
955.00	30	30	0	0	0	0	0	(OVERTOPPING)	

```
        PRESS: <1> TO PLOT TOTAL RATING CURVE
               <2> TO DETERMINE SPECIFIC INFORMATION ABOUT EACH CULVERT
               <3> TO SEE MULTIPLE CULVERT COMPUTATIONAL ERROR TABLE
               <4> TO PRINT CULVERT SUMMARY
               <ENTER> TO RETURN FOR NEW RUN OR EXIT
```

Changing Data

After reviewing the data for the first analysis, it is obvious that too much flow is overtopping the road with very little flow passing through the culvert. Thus another analysis will be performed with the overtopping elevation increased to 955.

Before leaving the first analysis be sure to save the file (for this example the file was saved under the name TEST).

```
SAVE MENU

TYPE LETTER OF DESIRED OPTION

<R> TO RENAME FILE

<F> FOR FILE LISTING

<S> TO SAVE FILE

<ENTER> TO RETURN
```

Return to the Culvert File Menu and select <E> to edit an existing file.

```
CULVERT FILE MENU

TYPE LETTER OF DESIRED OPTION

<E>   EDIT OR USE A FILE

<C>   CREATE A FILE

<ESC> FOR MAIN PROGRAM MENU
```

Select C for culvert data and select #2 to change the culvert size from 2 to 3 feet.

```
CIRCULAR CULVERT

CULVERT DIAMETER (FT) ---> 3*
```

Proceed with the overtopping analysis and obtain the following results.

SUMMARY OF CULVERT FLOWS (CFS) FILE: TEST DATE:

ELEV (FT)	TOTAL	1	2	3	4	5	6	OVERTOP	ITER
950.00	0	0	0	0	0	0	0	0	0
951.39	11	11	0	0	0	0	0	0	1
952.17	22	22	0	0	0	0	0	0	1
952.82	33	33	0	0	0	0	0	0	1
953.51	44	44	0	0	0	0	0	0	1
954.35	55	55	0	0	0	0	0	0	1
954.79	60	60	0	0	0	0	0	0	1
955.21	77	64	0	0	0	0	0	14	3
955.30	88	65	0	0	0	0	0	24	3
955.38	99	66	0	0	0	0	0	35	3
955.45	110	67	0	0	0	0	0	45	3
955.00	62	62	0	0	0	0	0	(OVERTOPPING)	

PRESS: <1> TO PLOT TOTAL RATING CURVE
<2> TO DETERMINE SPECIFIC INFORMATION ABOUT EACH CULVERT
<3> TO SEE MULTIPLE CULVERT COMPUTATIONAL ERROR TABLE
<4> TO PRINT CULVERT SUMMARY
<ENTER> TO RETURN FOR NEW RUN OR EXIT

This table shows that the design flow of 60 cfs will pass through the culvert while the additional flow from the 100-year storm will overtop the roadway.

Additional Analysis

Numerous other design selections could be analyzed included different culvert materials, improved inlets, different size culverts, etc. In addition, the model has another feature that is very useful. When the Summary Table appears on the screen there is an option <M> which will calculate the minimum size culvert need to accommodate the design flow given the other data provided in the analysis. Using this option, the following table shows that a 2.5 ft (30 inch) culvert could be used if the allowable headwater elevation could be increased to 957.21.

CULVERT ANALYSIS 3.1 DATE:
CULVERT FILE: TEST SUMMARY TABLE CULVERT NO. 1

CULV NO.	<S> SITE DATA: INLET ELEV. (FT)	OUTLET ELEV. (FT)	CULVERT LENGTH (FT)	<C> CULVERT SHAPE, MATERIAL, INLET: BARRELS SHAPE MATERIAL	SPAN (FT)	RISE (FT)	MANNING n	INLET TYPE
1	950.00	947.00	75	1 - RCP	2.50	2.50	.012	CONVENTIONAL
2								
3								
4								
5								
6								

HEADWATER ELEVATION		FLOW VELOCITY		FLOW DEPTHS	
ENTER ALLOWABLE =	958.00	CULVERT =	19.46	CULVERT =	1.50
CONTROLLING =	957.56	CHANNEL =	6.77	CHANNEL =	1.77
INLET CONTROL =	957.56	DISCHARGE =	60.00	NORMAL =	1.50
OUTLET CONTROL =	954.34	SLOPE =	0.0400	CRITICAL =	2.50

MAXIMUM HEADWATER <ENTER> TO CHANGE HEADWATER <ANY KEY> TO RETURN